Evaluation of Preemergent Herbicides for Newly Planted Blackberries

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Public Abstract

This trial assessed some of the preemergence herbicide options available and unavailable to growers and their effect on newly transplanted blackberries (*Rubus* L. subgenus *Rubus* Watson). This two-year field trial was initiated in 2021 and conducted at two locations: Milo J. Shult Research and Extension Center in Fayetteville, AR and the Fruit Research Station in Clarksville, AR. Seven treatments consisting of six preemergence herbicides (mesotrione, flumioxazin, oryzalin, *S*-metolachlor, pendimethalin, and napropamide) and one non-chemical weed-free (NCWF) check were applied to field plots of newly-transplanted tissue culture propagated blackberry plugs (var. 'Ouachita'). Preemergence herbicide treatments were applied with a CO_2-backpack sprayer calibrated to deliver 187 L/ha covering a 40-inch swath, ensuring spray pattern overlap over newly planted blackberries in 2021 and reapplied in the same manner to established blackberries of the same plots in 2022. Data was collected on visual injury, plant height, chlorophyll content, and green coverage of blackberry canopies and of bare ground portions of each plot. Yield data was collected in the second year, and fruit were analyzed for soluble solids content (°Brix), pH, and average berry weight. In the first year mesotrione and flumioxazin treatments caused significant damage to newly transplanted blackberries, and mesotrione treatments did not fully recover by 84 days after treatment (DAT). Napropamide, *S*-metolachlor, oryzalin, and pendimethalin did not exhibit injury over 6% throughout the 2021 season. In the second year (2022) no damage was incurred by any treatments. Results from these trials verify that labeled products flumioxazin, napropamide, oryzalin, and pendimethalin at the tested rates would be appropriate options for weed control in newly planted blackberries. These results corroborate the regional recommendations against the use of mesotrione in first year blackberry plantings. The findings from this trial indicate *S*-metolachlor would be safe for registration for use in blackberries, with regard to crop visual injury and to blackberry yield.

Objectives:

1. To determine the effect of preemergent herbicide applications on establishment and growth of newly transplanted blackberry plants in AR.
2. To generate data on weed control and crop response that can be utilized for regional recommendations and applications for supplemental labels for herbicides for blackberries grown in the southern region.

Introduction

Weeds compete directly with blackberries for water, nutrients, and light. Additionally, weeds may harbor insect pests or prevent air flow, favoring the development of foliar diseases. Current recommendations advise growing blackberries in a weed-free strip at least 4-ft wide to prevent yield loss from completive weeds (Mitchem & Jennings 2020). Weed-free strips allow blackberry plants to grow more vigorously, producing more primocanes and floricanes, and ultimately higher yields and fruit quality (Basinger et al. 2017; Meyers et al. 2014). Weed-free strips are typically maintained through the use of selective herbicides, dormant applications of nonselective herbicides, and preemergent herbicides to prevent weed emergence near blackberry plants. This weed management strategy is reliable for established blackberry plants; however, very few preeemergent herbicides are registered for use on first year blackberry plantings. The majority of preemergent herbicides are restricted to plants that have been established for more than 1 year (Table 1). New blackberry plantings, where plants are smallest and most vulnerable to weed interference, have the fewest options for chemical weed control. Thus, this proposal is designed to assess tolerance of newly established blackberry plants to several preemergent herbicides.

Table 1. List of commercially available preemergent herbicides for use in blackberry.

Common name	Trade name	WSSA MOA	Label restrictions for application
Dichlobenil	Casoron	20	Established plants only
Diuron	Karmex	7	Established plants only
Flumioxazin	Chateau	14	No restrictions[1]
Halosulfuron	Sandea	2	Washington and Oregon only
Indaziflam	Alion	29	Established plants only
Isoxaben	Trellis	21	Nonbearing trees/vines
Isoxaben + Trifluralin	Snapshot	21 + 3	Nonbearing trees/vines
Mesotrione	Callisto	27	No restrictions[1]
Napropamide	Devrinol	15	New plantings
Norflurazon	Solicam	12	Established plants only
Oryzalin	Surflan	3	Nonbearing trees/vines
Pendimethalin	Satellite Hydrocap	3	New plantings

[1] *Label has no restrictions for 1st year plantings (Anonymous 2018, 2019). Though recommendations are to apply only to plantings established 1 year or more (Mitchem and Jennings 2020).*

Rimsulfuron	Grapple	2	Established plants only
Simazine	Princep	5	New plantings
S-metolachlor	Dual Magnum	15	New plantings[1]
Sulfentrazone	Zeus XC	14	Established plants only (3 years or more)
Sulfentrazone + carfentrazone	Zeus Prime XC	14 + 14	Established plants only (2 years or more)
Terbacil	Sinbar	5	Established plants only

In perennial cropping systems, preemergent herbicides are used to prevent the germination of weed seeds, ideally causing no negative effects on the established crop. Industry and university research have demonstrated the safety of many preemergent herbicides in established blackberry plantings (Meyers et al. 2015; Peachey et al. 2012). Unfortunately, very little research is available assessing the effects of preemergent herbicides on newly planted blackberries. Thus, there is a critical need to investigate tolerances of newly planted (i.e. 1st year) blackberries to a selection of herbicides that may be safe for use and merit supplemental labeling.

Materials and Methods

Tissue cultured 'Ouchita' blackberries were planted in the spring of 2021 at the Milo J Shult (MJS) Research and Extension Center in Fayetteville, AR, and at the Fruit Research Station (FRS) in Clarksville, AR. Experimental plots measured 8-ft in length with four blackberry plants at 24-inch spacing with a 36-inch gap between plots (in-row) and 8 ft centers (between rows). Six preemegent herbicide treatments were replicated 4 times at each of two locations. Herbicide treatments include oryzalin, pendimethalin, *S*-metolachlor, flumioxazin, napropamide, and mesotrione. Preemergent herbicide applications were made using a CO_2-powered backpack sprayer (8002 EVS flat fan nozzles), calibrated to deliver 20 gallons per acre covering a 40-inch swath on each side of the plot. Treatments were applied within 72 hours after planting. Treatments will be repeated in early Spring 2022 on the same plots to assess the cumulative effect of repeat herbicide. Presumably, injury levels will be reduced with larger plants, which will be in the second year of growth, but the cumulative effect of injury will be quantified with yield data.

In the first year, data collected included weed control, crop injury, and primocane and floricane diameters. Crop injury ratings will be assessed relative to a weed-free plot. Weed control ratings of each herbicide were assessed visually by comparing treated plots to the untreated checks. In the second year, data will be collected on fruit number, fruit weight by harvest, and overall fruit weight across two harvests. Season-long weed control is not expected from any of the selected preemergent herbicides. To ensure plantings are not overrun by weeds before the end of the season, row middles were mowed regularly. Once preemergent herbicides have degraded, blanket applications of selected herbicides (e.g., paraquat, fluazifop) were sprayed uniformly on all plots. Weed control ratings will discontinue following blanket applications; however, crop injury ratings will still be assessed.

[1] *S-metolachlor was registered for use only in Washington and North Carolina, under 24(c) special local needs labels. These findings secured a 24(c) registration for Arkansas.*

Blackberry plants were maintained similarly to commercial production regarding fertility and cultural practices. A vertical trellis was installed for plantings at each site to maintain plant architecture. Pruning occurred as commercially practiced to ensure development of lateral buds (Fernandez et al. 2016; Strik et al. 2012). Insecticides and fungicides were applied as needed, following regional recommendations.

Results from this study will be used to guide recommendations for herbicide in new blackberry plantings, including the University of Arkansas Recommended Chemicals for Weed and Brush Control and the Southeast Regional Caneberries Integrated Management Guide (Barber et al. 2020; Mitchem and Jennings 2020). Data were used to secure a supplemental label and 24(c) registration of *S*-metolachlor (Dual Magnum) in Arkansas.

Results

Injury ratings

Five of the seven selected preemergent herbicides caused little to know visual injury to blackberries, across all rating dates (Table 2). Flumioxazin and mesotrione exhibited minor injury at both locations at 7 and 14 DAT. Flumioxazin symptoms were characterized by necrotic lesions on leaf surfaces, and mesotrione symptoms were primarily comprised of bleached foliage. Flumioxazin symptoms began to subside by 28 DAT and was undistinguishable from the nontreated plants after 42 DAT. In contrast, mesotrione injury became more apparent as time passed. The initial bleaching symptoms subsided after about 4 weeks, but plants remained stunted and had an overall reduced canopy size. Thus, visual symptoms shifted from acute herbicide symptoms to a general reduction in plant stature, which was corroborated by plant height data (Table 3). No injury was observed in response to any preemergent herbicide treatments in 2022 (data not shown).

Plant height and leaf chlorophyll content

Significant effects of herbicides on blackberry plant heights were detected 14 DAT, but it was not a particularly substantial effect (plants varied by < 2 cm), and no significant herbicide effect at 28 DAT (Table 3). At 56 DAT, blackberry plant heights were significantly reduced in plots treated with mesotrione; no other herbicides had an effect on plant heights at that rating date. At 84 DAT, treatment with mesotrione resulted in the shortest plants at both MJS and FRS. It is worth noting that flumioxazin, *S*-metolachlor, and oryzalin applied in MJS reduced blackberry plant heights relative to the untreated control. The only herbicide that caused any reduction in leaf chlrophyll content was mesotrione (Table 3). At both locations, mesotrione caused significant reductions in leaf chlorophyll content at 14, 28, and 56 DAT. By 84 DAT, no herbicide treatments caused any significant difference in leaf chlorophyll content. No significant differences were detected in SPAD measurements in 2022 (data not shown).

Yield

The effect of herbicide or herbicide × location was not significant on blackberry yield at any harvest timing, cumulative harvest or average berry weight (Table 4). This was a surprising result, considering the mesotrione treatment caused severe crop injury, reduced plant height, and reduced blackberry green cover in the 2021 season (data not shown). This finding indicates that blackberry plants recover from initial injury from mesotrione and produce similar yields to non-injured plants. A possible explanation of recovery could be that pruning activity between 2021 and 2022 brought all blackberry

plots back to a similar growth status and plant stature. Then, the second-year plants were not sensitive to the mesotrione applications; however, no data was collected on pruning weights to determine this for certain. Despite consistent yields, the high levels of injury caused by mesotrione support the current commercial recommendation to apply the product only to established blackberries (Mitchem & Jennings 2020). Other studies and best practices have shown that maintaining the WFSW keeps plants healthy which in turn promotes yield (Basinger et al. 2017; Childers et al. 1995; Fernandez & Ballington 1999; Meyers et al. 2014; Meyers et al. 2015). Throughout this trial the WFSW was maintained for all plots, so any disparities in yield can be attributed to the effects of the preemergence herbicide rather than weed interference.

Postharvest quality

Fruit quality is important for consumers, particularly for fresh market crops, like blackberry (Threlfall et al. 2016). Thus, it is critically important to assess quantitative traits that characterize fruit quality of blackberries in response to the selected herbicides. Similar to the findings with yields, no detrimental effects of herbicides on fruit quality were observed (Table 4 & 5). Blackberry pH varied more greatly between harvests than among herbicide treatments. No substantial variation in pH or °Brix was observed among and treatments or harvests. These findings are consistent with other work which has demonstrated measures of soluble solids content or pH are generally maintained under most stressors or fertility source (Basinger et al. 2017; Meyers et al. 2014). Fruit quality such as soluble solids and firmness are often determined by cultivar selection, or the rate of fertilizers applied (Fernandez-Salvador et al. 2015; Nelson & Martin 1986). Therefore, herbicides in this trial had no negative effects on any measurable trait associated with fruit quality and would offer no cause for concern for commercial blackberry production.

Discussion

First year data indicate that mesotrione may not be suitable for application on first year plantings of blackberries, due to extensive crop injury, reduced leaf chlorophyll content and reduced plant height. This aligns with regional recommendations (Mitchem and Jennings 2020), though there are no restrictions on the Callisto® label for first year blackberry plantings (Anonymous 2018). Flumioxazin is another potentially problematic herbicide due to the severity of herbicide symptoms on small plants. Despite the lack of injury symptoms at later evaluation dates, it is likely that the observed injury would be unacceptable for newly planted blackberries. This could be overcome by ensuring that flumioxazin does not come into contact with plant foliage, which would require additional investment in shielded applications or grow tubes. More promising are the results with *S*-metolachlor, napropamide, oryzalin, and pendimethalin, none of which exhibited any crop injury above 5% in the entire trial. It was expected that napropamide and oryzalin would cause little to no injury because these products are already labeled for use in newly planted blackberries. It is promising that no injury was observed in response to *S*-metolachlor, which until recently did not have a 24(c) registration for use in blackberries in Arkansas. Lastly, it is encouraging that plants treated with pendimethalin exhibited no injury symptoms. Pendimethalin would be a very valuable new herbicide for registration in blackberries, particularly with the periodic difficulties in acquiring oryzalin in some years.

Conclusion

Broadening chemical control options and producing data that can inform recommendations were the driving forces for investigation. Though the mesotrione treatment did inflict unacceptable levels of damage in the first year (2021) there was no statistical difference in yield the following year (2022). Flumioxazin did inflict injury at unacceptable levels but quickly grew out of the damage and was, in most cases, statistically similar to the NCWF check in 2021 and caused no injury in 2022 at all. Oryzalin, *S*-metolachlor, napropamide, and pendimethalin exhibited no detrimental effect to blackberries in our trials. No statistical evidence was found to demonstrate yield reductions or a decrease in fruit quality in response to preemergence herbicide treatments. In 2022, when plants were more established, there were no detectable effects of preemergence herbicides on leaf chlorophyll content, visual injury, yield, or fruit quality. This field trial found that damage observed in the first year (2021) did not affect fruit quality or yield in the following season. Based on results from this trial, mesotrione and flumioxazin would not be recommended for use as a broadcast application with potential foliar interception in first year blackberry plantings due to the unacceptable levels of injury observed. These findings validate many of the regional recommendations and provide new evidence to consider expanding registration and labeled usage requirements for materials such as oryzalin, *S*-metolachlor, and pendimethalin. It is important to acknowledge the inability of this research to predict the effects of the selected herbicides on first year harvests from primocane-fruiting blackberry varieties. While we observed no deleterious yield effects of selected herbicides in second year harvests, it is possible that the injury symptoms could reduce yields in first year primocane harvests. More research would need to be conducted to specifically quantify those responses, but there is evidence that unacceptable levels of injury were observed in response to mesotrione in first year plantings, regardless of yield outcomes.

Table 2. Summary of visual injury of blackberries treated with preemergent applications of several herbicides applied in Fayetteville, AR and in Clarksville, AR.[z]

	Injury rating									
	7 DAT		14 DAT		28 DAT		42 DAT	56 DAT	84 DAT	
Herbicide[y]	FRS	MJS	FRS	MJS	FRS	MJS	Both	Both	FRS	MJS
	%									
Mesotrione	6.3 b	5.0 b	13.8 a	10.0 a	12.5 a	31.3 a	55.6 a	41.3 a	28.8 a	57.5 a
Flumioxazin	10.0 a	10.0 a	15.0 a	7.8 ab	2.5 b	12.5 b	2.5 b	4.4 b	0.0 b	2.5 b
Napropamide	0.0 c	0.0 d	0.0 b	0.0 d	0.0 b	0.0 c	0.0 b	0.6 b	0.0 b	1.3 b
S-metolachlor	0.0 c	5.0 b	0.0 b	0.0 d	0.8 b	0.0 c	0.0 b	0.6 b	0.0 b	1.3 b
Pendimethalin	0.0 c	1.3 cd	1.5 b	1.3 cd	0.0 b	2.5 c	0.0 b	0.0 b	0.0 b	0.0 b
Oryzalin	0.0 c	2.5 c	0.0 b	4.5 bc	0.0 b	5.0 c	0.6 b	0.6 b	0.0 b	3.8 b
Factor	*P value*									
Herbicide (H)	<.0001	<.0001	<.0001	<.0001	0.0011	<.0001	<.0001	<.0001	<.0001	<.0001
Location (L)	-	-	-	-	-	-	0.4820	0.4606	-	-
H × L	0.0004		0.0053		0.0005		0.5279	0.4756	0.0013	

[z]Abbreviations: DAT = days after treatment, FRS = Fruit Research Station (Clarksville, AR), MJS = Milo J. Shult Research and Extension Center (Fayetteville, AR).

[y]Herbicide rates: mesotrione (2.25 oz ai/A), flumioxazin (3 oz ai/A), napropamide (4 lb ai/A), *S*-metolachlor (1.42 lb ai/A), pendimethalin (3 lb ai/A), and oryzalin (2.4 lb ai/A)

Table 3. Summary of blackberry plant heights and leaf chlorophyll content in response to preemergent herbicides applied in Fayetteville, AR and in Clarksville, AR.[z]

	Plant height					Leaf chlorophyll content				
Herbicide[y]	14 DAT[z]	28 DAT	56 DAT	84 DAT		14 DAT	28 DAT	56 DAT		84 DAT
	Both	Both	Both	FRS	MJS	Both	Both	FRS	MJS	Both
	cm					SPAD				
Mesotrione	11.0 a	11.7	20.6 b	59.9 b	78.8 d	33.38 b	34.81 b	35.62 b	41.93 b	49.57
Flumioxazin	9.3 b	11.9	34.4 a	117.9 a	132.5 c	42.23 a	45.97 a	44.19 a	45.01 a	51.85
Napropamide	10.9 ab	13.0	39.1 a	108.4 a	156.3 ab	42.87 a	47.48 a	46.34 a	47.33 a	52.28
S-metolachlor	11.1 a	19.3	39.4 a	109.8 a	141.8 bc	43.30 a	48.02 a	44.25 a	45.18 a	50.78
Pendimethalin	11.6 a	13.3	35.9 a	105.9 a	147.0 abc	42.58 a	48.43 a	46.13 a	45.80 a	51.43
Oryzalin	11.1 a	13.6	35.4 a	109.1 a	134.8 bc	42.36 a	50.23 a	46.48 a	45.81 a	52.42
Untreated	10.9 ab	12.6	35.4 a	104.1 a	165.4 a	43.23 a	45.89 a	46.86 a	47.74 a	50.59
Factor	*P value*									
Herbicide (H)	0.0042	0.3748	<.0001	0.0001	<.0001	<.0001	<.0001	<.0001	0.0118	0.4224
Location (L)	0.0158	0.2439	0.6185	-	-	0.2113	0.1240	-	-	0.0046
H × L	0.6085	0.3995	0.3015	0.0455		0.9233	0.1882	0.0452		0.3691

[z]Abbreviations: DAT = days after treatment, FRS = Fruit Research Station (Clarksville, AR), MJS = Milo J. Shult Research and Extension Center (Fayetteville, AR).

[y]Herbicide rates: mesotrione (2.25 oz ai/A), flumioxazin (3 oz ai/A), napropamide (4 lb ai/A), *S*-metolachlor (1.42 lb ai/A), pendimethalin (3 lb ai/A), and oryzalin (2.4 lb ai/A)

Table 4. Blackberry yield by harvest, initiated at Fayetteville, AR June 28, 2022, and Clarksville, AR June 20, 2022. Harvested twice a week and final harvests took place in Fayetteville, AR July 29, 2022, and Clarksville, AR July 21, 2022. Cumulative marketable, cull yields, and average berry weight for 2022 blackberry harvest.[a]

Herbicide	Blackberry Yield											
	Harvest[b] 1	Harvest 2	Harvest 3	Harvest 4	Harvest 5	Harvest 6	Harvest 7	Harvest 8	Harvest 9	Cumulative marketable[c]	Cumulative cull[d]	Avg. weight
	kg/plant											
Mesotrione	0.26	0.21	0.48	0.34	0.37	0.15	0.17	0.11	0.12	2.22	0.25	5.28
Flumioxazin	0.29	0.29	0.57	0.37	0.33	0.15	0.18	0.13	0.14	2.45	0.35	5.30
Oryzalin	0.29	0.27	0.49	0.36	0.38	0.15	0.20	0.15	0.17	2.47	0.35	5.21
S-Metolachlor	0.31	0.24	0.60	0.44	0.45	0.16	0.21	0.15	0.17	2.72	0.29	5.19
Pendimethalin	0.31	0.28	0.51	0.39	0.39	0.16	0.22	0.16	0.16	2.59	0.31	5.28
Napropamide	0.27	0.28	0.55	0.42	0.40	0.17	0.22	0.17	0.22	2.70	0.27	5.28
Handweeded	0.27	0.25	0.52	0.39	0.40	0.17	0.20	0.15	0.18	2.55	0.28	5.23
P-value	0.9310	0.1446	0.4356	0.5635	0.7187	0.9150	0.4806	0.1450	0.3097	0.6332	0.4494	0.9902

[a]Means were separated using Tukey's Honest Significant Difference at a α=0.05 significance level and means followed by the same letter are not significantly different.

[b]Harvests reflect only marketable berry yields.

[c]Marketable yields were defined as ripe berries without blemish.

[d]Cull yields were defined as berries that did not meet marketable standards through damage or malformation.

Table 5 Blackberry fruit quality data assessed on bulked samples of 10 marketable quality macerated berries from each plot in Fayetteville, AR and Clarksville, AR.[a]

	Postharvest Fruit Quality[b]							
Herbicide	Harvest 2[a]	Harvest 5	Harvest 7	All harvests	Harvest 2	Harvest 5	Harvest 7	All harvests
	pH				°Brix			
Mesotrione	3.42	3.71	3.63	3.58	10.62	10.96	10.85	10.81
Flumioxazin	3.40	3.67	3.55	3.54	10.71	10.75	11.20	10.88
Oryzalin	3.42	3.47	3.53	3.56	10.82	10.91	10.81	10.85
S-Metolachlor	3.40	3.74	3.62	3.58	10.41	10.71	11.37	10.83
Pendimethalin	3.41	3.62	3.56	3.53	10.96	10.77	11.10	10.94
Napropamide	3.36	3.70	3.59	3.55	10.40	10.11	10.92	10.47
Hand-weeded	3.37	3.72	3.52	3.53	11.27	11.25	10.91	11.14
P-value	0.9573	0.1806	0.1223	0.6606	0.6082	0.1901	0.7670	0.2985

[a]Means were separated using Tukey's Honest Significant Difference at a α=0.05 significance level and means followed by the same letter are not significantly different.
[b]Quality data were collected on a subset of harvest throughout the season. Harvests are indicated chronologically with harvests 2, 5, and 7 occurring on July 2, 12, and 19 or June 23, July 5, and 11 for Fayetteville and Clarksville, respectively.

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